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SCINTILLATION COUNTING WITH AN E. M. I. 5311 PHOTOMULTIPLIER TUBE*

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ABSTRACT

The EMI 5311 photomultiplier tube differs from the usual tube in that the electrodes are of the Venetian blind type rather than sections of electron optical lenses. This type of tube has been used as a scintillation counter with trans-stilbene crystals. The shape of the scintillation pulse in characterized by a rise time of 7.2×10^{-9} sec. and a decay time of 1.8×10^{-8} sec., It is concluded that this type of multiplication structure results in an unusually large spread in the transit time of electrons moving through the structure.

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ARTICLE

A new type of photomultiplier tube has been described by Sommer and Turk[1]. This tube has eleven multiplying electrodes of the Venetian blind design and a flat, semi-transparent photocathode at the end of the tube envelope. The effective diameter of the photocathode is approximately one inch and has a spectral response similar to that of the S-9 surface used in the RCA 5819 tube.

The properties of this type of tube, used as a scintillation counter, have been studied with the following arrangement. The potential divider for the multiplier tube consisted of 12 - 330K resistors by-passed by .001 μf condensors. The collecting electrode was connected to a distributed amplifier by 150 feet of RG-7U cable and also to a trigger amplifier by 3 feet of the same type of cable. Since these two cables were in parallel, the signal at the multiplier output appeared across a load of 48 ohms. The output of the final power amplifier was displayed on a 5XPII cathode ray tube. The rise time of the signal amplifiers when connected to the scope was about 3.8×10^{-9} sec. (10 to 90% value).

Preliminary tests have indicated that voltages up to 5 K.V. may be applied to the 5311 tube before breakdown occurs. In order to indicate the characteristics of this tube as a scintillation counter, photographs have been made of the noise pulses and scintillation pulses from a trans-stilbene crystal.

The scope traces shown in Fig. 1 represent noise pulses observed when the tube was operated at 3400 and at 5000 volts. The rise times of these noise pulses are slightly longer than that of the distributed amplifier. The most striking characteristic of these pulses is the long decay time of approximately 10^{-8} seconds.

The scintillation pulses shown in Fig. 2 were obtained when a trans-stilbene crystal 5 mm thick was cemented with Canada balsam to the flat photo-cathode. A source of Co^{60} gamma radiation was used to produce the scintillations. As in the case of the noise pulses, the rise times are

longer than that of the amplifier. The decay times also appear to increase with increasing voltage. For comparison, a trans-stilbene pulse observed with an RCA 5819 tube operated at 1400 volts is included. In this case the rise time of the pulse is almost exactly equal to that of the amplifier, and the decay time agrees with published values[(2)]. The error in all measurements is probably of the order of 15%.

The relatively long rise times and decay times of the pulses from the 5311 tube must be caused by an unusually large spread in the transit time of the electrons passing through the multiplying electrodes. The most logical explanation of this spread in time is that, as the voltage between stages is increased, a greater proportion of the primary electrons incident upon a given surface is scattered and finally reaches the next electrode ahead of the secondaries ejected from this same surface. In addition to this spread in transit time there is the usual variation caused by the combined effects of different effective path lengths between successive electrodes and the different emission velocities of the secondary electrons. The magnitude of this latter effect is difficult to estimate without a knowledge of the potential distribution within the Venetian blind electrodes.

We may conclude from these observations that the type of photomultiplier using the Venetian blind system of multiplication is characterized by unusually broad pulses. This will prove to be a serious limitation to the resolving power of this tube when operated as a scintillation counter using a fast crystal such as trans-stilbene. The tube should be entirely suitable for use with slow inorganic crystals such as Thallium activated NaI.

(1) A. Sommer and W. E. Turk, Journ. of Sci Inst. 27 113, (1950)

(2) O. Martinson, P. Isaacs, H. Brown and I. W. Ruderman, Phys. Rev. 79 178, (1950)

CAPTIONS

Fig. 1: Typical noise pulses from the E. M. I. 5311 photomultiplier tube. The first trace, taken at 3400 V., indicates a rise time of 5.0×10^{-9} sec. and a decay time of 1.0×10^{-8} sec.. The second trace, at 5000 V., shows a rise time of 6.0×10^{-9} sec. and a decay time of 1.2×10^{-8} sec.. Rise times are taken from 10% to 90% pulse height, while decay times are measured to 1/e, assuming exponential decay.

Fig 2: Typical scope traces with a trans-stilbene crystal. Traces (a), (b), and (c) were obtained with the E. M. I. 5311 tube, operated at 2800, 3500 and 4500 V, respectively. Trace (d), included for comparison, is that obtained with the RCA 5819, operated at 1400 V. Rise and decay times are as follows: (a) $T_R = 7.2 \times 10^{-9}$ sec., $T_D = 1.8 \times 10^{-8}$ sec.; (b) $T_R = 7.2 \times 10^{-9}$ sec., $T_D = 2.8 \times 10^{-8}$ sec.; (c) $T_R = 6.6 \times 10^{-9}$ sec., $T_D = 3.2 \times 10^{-8}$ sec.; (d) $T_R = 4.0 \times 10^{-9}$ sec., $T_D = 7.0 \times 10^{-9}$ sec. Note the amplifier and cable reflections which become increasingly more prominent at higher voltages.

(a)

(b)

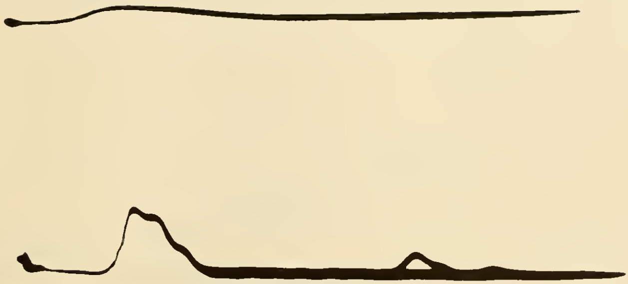

FIGURE 1

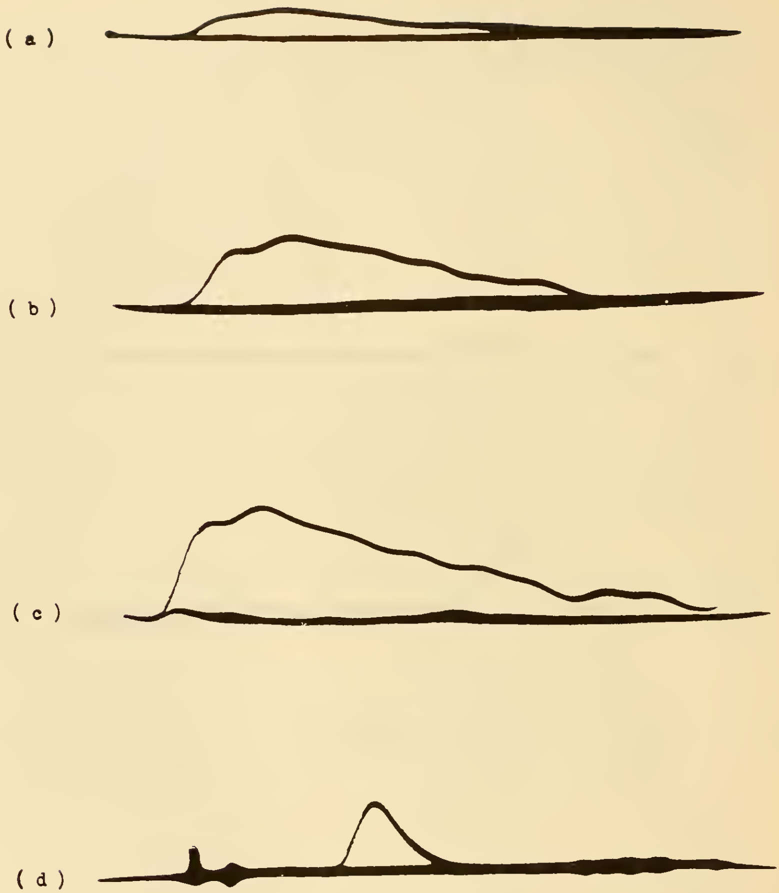

FIGURE 2

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